way adequate provision may be made for the larger vocational interests represented by college students of serious purpose and well matured plans. An inspection of the provisions will at once make clear that the conception of vocational training is broad and catholic, and not in any way to be identified with the occasionally narrow and shallow training afforded by so-called vocational schools.

JAMES ROWLAND ANGELL
THE UNIVERSITY OF CHICAGO

THE MAN OF SCIENCE AND HIS DUTIES[1]

I HAVE been laboring with some uncertainty, in an effort to determine what would be most suitable for an occasion of this kind. Shall I read a text, or shall I sound a key-note? Perhaps either or both would be in harmony with the occasion. For it is the aim of this society to promote what I consider the highest interests of mankind. We are to give every possible encouragement to those who seek to widen the boundaries of human knowledge. The world is beginning to learn how all-important it is that this should be done. We no longer need to spend any time in contending for such ideas. We only need to ask the doubter to read history, and to open his eyes to his surroundings. The boundary of human knowledge has been widening in a way that must excite our wonder. Like the four sages, of whom Dante has given us a beautiful picture, we stand in the hemisphere of light that has been kindled in our midst, and which slowly pushes back the surrounding darkness. But this only serves to reveal, more and more, the immensity of the region of darkness which still lies beyond. I wish to emphasize on every proper occasion, and certainly on this occasion, that the men who have earned and deserve the peculiar and special gratitude of their successors, are the men who could by no means foresee the value of their work.

[1] Address of the president of Washington Chapter Sigma Xi.

Think for a moment of what the world owes to Michael Faraday. He never suspected the value of his work. The most learned men of his day were interested in his results, but they could not foresee their value. He was a man who had none of the advantages which a college student of to-day so often neglects. The son of a blacksmith, he was apprenticed to a bookbinder. While at this labor, he attracted the attention of Sir Humphry Davy, who was in charge of the laboratories of the Royal Institution. And this institution, by the way, was founded by a former teacher in a New England school, who became Count Rumford, and who was one of the greatest men that America has produced.

Faraday became the assistant of Davy, and he remained in the institution for fifty-four years. At the age of forty-two his merits were recognized by the governing board, in an action which relieved him of all lecture and instruction work. This was also a recognition of an obligation which they owed to the world.

Consider the results of one fragment of his work: On September 22, 1831, two years before he was relieved of instruction duties, Faraday wrote in his note-book as follows:

I have had an iron ring made (soft iron), iron round and $\frac{7}{8}$ of an inch thick, and ring six inches in external diameter. Wound many coils of copper round one half of the ring, being separated by twine and calico. There were three lengths of wire, each about 24 feet long, and they could be connected as one length or as separate lengths. By trial with a trough, each was insulated from the other. We will call this side of the ring *A*. On the other side, but separated by an interval, was wound wire in two pieces, together amounting

to about 60 ft. in length, the direction being as with the other coils. This side call *B*.

Charged a battery of ten plates, four inches square, made the coil on *B* side one coil, and connected its extremities by a copper wire passing to a distance and just over a magnetic needle (three feet from iron ring). Then connected the ends on one of the pieces on *A* side with the battery: immediately a sensible effect on needle. It oscillated, and settled at last in original position. On breaking connection of *A* side with the battery, again a disturbance of the needle.

Later he varied the experiment and writes:

In place of the indicating helix, our galvanometer was used, and then a sudden jerk was perceived when battery communication was *made* and *broken*, but it was so slight as to be scarcely visible. It was one way when made and the other way when broken, and the needle took up its natural position at intermediate times.

The device which Faraday described was a transformer. The impulses which he saw in the needle were due to induced currents. He was at once led by this to the invention of the first dynamo, which he constructed during the same month.

If any person had asked Faraday that exasperating question, what is all this worth in pounds, shillings and pence, or what are your services really worth per student hour, he would have been utterly unable to make a satisfactory reply. The effects were so minute that it was with difficulty that they could be seen. The forces involved were utterly insignificant. His dynamo was worthless as a machine. Who could then have imagined that these feeble impulses would some day be pumped through wires to light large cities, and to move heavy cars loaded down with passengers? Who could have then believed that articulate speech would ever be transmitted by them? Who could then have believed that ships on the ocean would some day be in constant communication with the land, by means of such impulses transmitted through space, and that a ship in distress would thus be able to call for help? Had any prophet foretold all of this at that time, it would have been called the idle fancy of a foolish brain. And yet all of these great things followed directly from those simple experiments.

And the end is not yet. We are beginning to see the importance of saving our fuel. We may be able to grow trees, but we can not grow coal. An age of water power is before us when vast amounts of power will be thus obtained, and transmitted, by these methods devised by Faraday, to distant cities. Millions upon millions of dollars are now invested, and vast armies of men are employed in enterprises which followed directly from these simple experiments.

When Helmholtz visited London in 1853 he wrote to his wife an account of his visit to Faraday, in which he says:

Those were splendid moments. He is as simple, charming and unaffected as a child; I have never seen a man with such winning ways. He was, moreover, extremely kind, and showed me all there was to see. That indeed was little enough—for a few wires and some old bits of wood and iron seem to serve him for the greatest discoveries.

It is often said that work of such character is not for all; that only a few of the elect are capable of doing it. In a sense this is true. There are comparatively few who will in their younger days submit to the agonizing struggle through which one must go, in order that he may gain control of his mental faculties. If he is mentally slow in his sense perception, it will be necessary for him to engage, persistently, for hours, days and years, in a mental struggle with problems which tax his utmost powers. It is in this way that one finally acquires the capacity for careful and logical and persistent thinking. It goes without saying that there are comparatively few who will submit to such an

initiation. Certainly the average man is not and never has been of that class. Such men are thinking men. In their younger days most men are disposed to criticize the work of others. Among men of science this is much less common than it was thirty or forty years ago. Every one who has ever accomplished anything will recognize the truth of Goethe's remark:

> It is easier to recognize error than to find truth. That lies upon the surface so that it is easily dealt with; this rests in the depths, to search for which is not every man's affair.

As one's powers develop and he begins to attack constructive work, and to make mistakes, he begins to take less interest in searching for errors in the work of others. To search for truth is any man's affair who chooses to do so. And history tells us in no uncertain way that human development has always resulted from the efforts of those who have expended most of their energy in independent thinking. Sometimes the world has followed slowly. Sometimes the results have only become apparent in succeeding generations. Our industrial development has, however, always followed in the pathways marked out by scientific men. Their work has always preceded the work of the engineer and the inventor. And in the words of my text, When any nation has reached such a stage in its existence, that scientific discovery is put into the background as of no practical value, and the entire current of work is expended in engineering and business activity, that nation is on the way to the civilization of China.

As a nation we have before us problems that are vastly greater than any which have been solved in the past. We may assume that the future will take care of itself. We may assume that our leaders in thought and in knowledge will always be with us. We should, however, remember, that there have been former civilizations in other lands, of which no trace can now be obtained, without digging below the surface of the earth.

The question which should now interest us is, whether or not our civilization is to have such an ending.

It is only a century ago since one of my ancestors moved with his family from Vermont to the far west. There were few roads amid the immense forests through which they wandered, and in the midst of which the family finally found a home in central New York. I personally knew, and still remember the names of some of the men who developed that country. What they did was to chop down forests and burn them. What they then did should now be called by another name.

There are now among us men who are ambitious to waste the resources of the country, on the plea that they are developing those resources. They protest strongly against the importation of lumber from Canada, because it would interfere with the chopping down of our own trees. Fifty years ago there was not a locomotive engine in the country which was operated by coal fires. They were all operated by wood fires. The locomotive of to-day could not be operated by wood fires, and the wood is no longer available. Then a 100-ton locomotive would have been considered an impossibility. The bridges of that day would not have sustained them. At that time a 30-ton locomotive was in general use. Now we have locomotives which approach 300 tons. Thirty years ago the idea that 1,000 horse-power engines would be used for developing power to be distributed by electrical means was ridiculed as absurd by electrical authorities.

Even if we take the most liberal estimate of the amount of available coal yet unburned, and consider the enormous in-

crease in its consumption, we must still admit that the burning of coal is a mere incident in human history. It seems to me that it is the duty of thinking people to begin to think about such things. Why should they be left to those who are continually planning to perfect and legalize schemes of public robbery? The people of the country are waiting for leaders, who have been trained in methods of careful and logical thinking, who not only are not for sale, but who can not be bought, and who are not afraid.

There are other duties which are demanded of thinking men. It is evident that the honest public needs light on many questions which are of vital interest to all. It is possible to fool nearly half of the people, nearly all of the time. For example, there are many well-meaning people to whom it would never occur that the citizens of Missouri need protection against Iowa, or Arkansas, who can be made to believe that the people of the United States need protection against Canada, or Germany or England.

What we do need protection against, first of all, is organized systems of bribery and public robbery.

I know of men who have given attention to such public matters, who have engaged in a successful private business, and who among a wholly different class of men are regarded as authorities in some branch of scholarly or scientific work. The man who has scholarly tastes, the man who appreciates the value of those things which money can not buy, is not likely to be dominated by the insane greed which seems to have taken possession of such a large class of our citizens. He may appreciate the approval and gratitude of those whom he has helped, and to whom his life has been an inspiration. He is not dominated by a desire to attract attention. Certainly he will not seek to attract attention by spectacular or ostentatious waste of ill-gotten gains.

Perhaps we should not be far from the truth if we lay down as a fundamental axiom, that men's lives are guided by a desire to secure personal enjoyment or pleasure. The differences between men arise when we observe from their behavior, what it is that gives pleasure to them. Some will undergo hardships and distress, for the joy of attaining a worthy end. Some will spend their earnings for the pleasure of a midnight carouse. The searcher for the unknown in nature will spend years of labor and mental toil, in the hope that he may feel the joy of finally adding his mite to the store of knowledge which his predecessors have given to the world. Such work as this is often attended with a feeling which might properly be called mental distress.

In the twenty-fourth series of his "Experimental Researches" Faraday describes many tedious and intricate experiments in which he sought to discover some relation between electrical action and gravitation. As his biographer tells us, "He labored with characteristic energy for days, on the clock-tower of the Houses of Parliament and in the shot-tower of Southward, raising and lowering heavy weights connected with wire coils." Many times his results appeared for a time to furnish conclusive proof of his assumption. Then came a period of self criticism, and of doubt, and when the final end was reached, there remained absolutely no result. As Faraday described his mental condition, "Occasionally, and frequently, the exercise of the judgment ought to end in absolute reservation. We are not infallible, and so we ought to be cautious." On another occasion he said:

The world little knows how many of the thoughts and theories which have passed through the mind of the scientific investigator, have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances, not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realized.

It is a matter of common observation that men who have done most to widen the boundaries of human knowledge, are the ones who are most frequently in a state of doubt. They are always ready to take the whole matter into consideration again when some preliminary conclusion is confronted with conflicting evidence. In physics where we seek the relation between various values which are simultaneously involved in some function, as in the bending of a beam under a load, we can vary one quantity only, and find its effect on the result. When this has been done with all of the variables which are concerned, the entire equation involving the simultaneous effect of all the variables can be written. When we undertake to determine the effect upon a nation, of some national policy, we are never able to control conditions in two successive experiments. We can not eliminate the disturbing effect of other influences or conditions which have also changed and which are of importance in determining the result. But the political orator is never in doubt. He speaks with as much of assurance as a lawyer, who argues a case in court.

It is not the duty of a scientific man to defend what is generally believed to be the truth. The mental attitude of the advocate is foreign to every instinct that the man of science should possess. In Galileo's time we can well understand how the man of science should actively contend in quarrelsome debate with those who refused to look through his telescope. It was enough for them to know that there were seven openings in the head, seven metals, and seven days in the week. This was proof enough that there could only be seven planetary bodies. The moon and the sun were perfect as they came from the hand of the creator. This was proof enough that there could be no mountains and valleys on the moon, and no spots on the sun. It needs no telescope to settle such questions. That all bodies do not fall with the same acceleration has been already passed upon in a prior decision. It is sufficient to cite that opinion, and Galileo's experiment at the tower of Pisa counts for nothing.

Galileo was himself a product of an age characterized by ideas of this kind. In his day his mental attitude was perhaps needful. There are times when the soil must be plowed. In our time the man of science is free to go his own way in the pursuit of his work and in publishing it to the world. If one feels dissatisfied with the present, he can do nothing better than to read history.

I have often felt that scientific students of our time would be greatly benefited by reading much more of history than is their custom. There are some most interesting remnants of scientific history, connected with the Moorish occupation of Spain. The work of Alhazen, who lived about 1100 A.D. would have been creditable in any age. It requires great patience for one living in this age to read European history during the times of Luther and Galileo. It is, however, only in this way that we can realize what progress the world has been making.

It is, however, a satisfaction to know that nations have never been driven to bloody wars in order to enforce the doctrine of universal gravitation, or Kepler's third law, or the doctrine of evolution.

We do learn that in those earlier times,

a public official who would dare to interfere with princely schemes of public robbery, would generally lose his head. Now he at most loses his position. Our merchant princes are not so severe as their predecessors were.

The barber of the present day is not expected to do surgical work, although his sign still gives notice that accidents may happen. The bloody pole with its white bandage reminds us of the days when the barber was the surgeon. The family of Poisson decided for him in his youthful days that the work of a notary required greater intelligence than he possessed, and advised him to become a surgeon. It was not until 1745 that the "barberous" work of the surgeon and the surgical work of the barber were, in England, eliminated by law.

Not only should one study the history of the arts and sciences, but even more inspiring are the biographies of the great men of history. Most of the men who have given direction to scientific thought and work have been men who came from the most humble positions in life. Occasionally we find one coming from so-called higher levels, who was not satisfied to be simply a descendant. To read an account of the work of such men, in connection with the human element which enters into a biography, often opens up a new world to a young man. He may thus learn that he possesses elements which respond to such history. It is not saying too much to say that the great mass of students in college never come into contact with the great things of the learned world. They do not do enough of skirmishing in the fields of learning. They waste their time in trivial matters which will have little value to them in the future. They perhaps never acquire the faintest knowledge of branches of learning, which, if they knew of them, would change the whole current of their lives.

And in order that one may do new work it is not necessary to hunt for new fields. Remember that the Crookes tube was in physical laboratories in all parts of the world for seventeen years, before any one suspected that it was an X-ray tube. Röntgen was hunting for accidents of the kind, and he accidentally discovered that there were phenomena outside of the tube that demanded attention. It is only needful that one shall read and think, and the work of others, which may have been published half a century ago, will suggest something to you which it never suggested to any one before, and which may occupy your attention for years.

FRANCIS E. NIPHER

BRITISH VITAL STATISTICS

THE British Registrar-General has issued his return relating to the births and deaths in the first quarter of the year, and to the marriages during the three months ending December last. From the abstract in *The British Medical Journal* it appears that the marriage-rate during that period was equal to 16.1 per 1,000, or 0.7 per 1,000 less than the average rate for the corresponding quarter in the ten preceding years.

The 223,588 births registered in England and Wales during the quarter under notice were equal to an annual rate of 24.8 per 1,000 of the estimated population; the birth-rate last quarter was 2.7 per 1,000 below the average rate for the corresponding period of the ten preceding years, and is the lowest birth-rate recorded in the first quarter of any year since the establishment of civil registration. Among the several counties the birth-rates ranged from 17.8 in Carnarvonshire, 18.5 in Sussex, 19.6 in Northamptonshire, 20.1 in Kent, and 20.6 in Dorsetshire and in Gloucestershire, to 29.1 in Nottinghamshire, 31.3 in Carmarthenshire, 31.4 in Durham, 34.5 in Glamorganshire and 35.9 in Mon-